Comparison of unfiltered CERES radiances measured from the Suomi-NPP and Aqua satellites over matched sites

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Opening Remarks

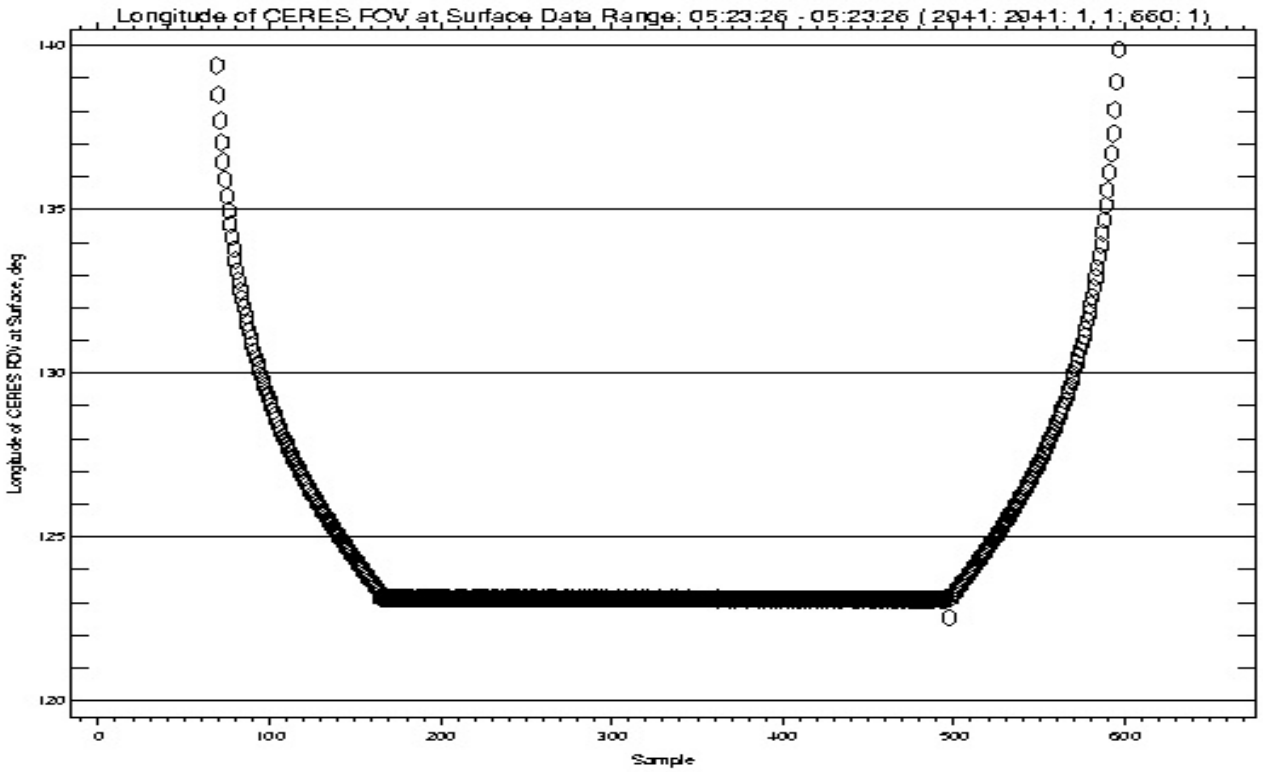
- FM5 on S-NPP has delivered 3+ years of science data
  - Question about consistency of FM5 with FM3/FM1
  - FM5/FM3 orbits afford various strategies for comparison
    - Simultaneous, as they fly in "tandem" every 64 hours
      - All-sky results for SW, LWD, and LWN
    - Over the same sites, as satellites fly over them within 5 minutes
      - Specific scene type results
  - Comparison of unfiltered radiances to avoid uncertainties of ADMs
    - Results using Edition 1 for FM5 and Edition 4 for FM3
    - Cloud coverage provided by Aqua MODIS (Edition 1)
- There were 13 nadir dwell observations in 2013/2014
  - The use of a nadir dwell scan profile is an enabler

Strategy: "Matched sites targeting"

- FM5 and FM3 use a nadir dwell scan profile
  - $\Delta T < 5$ minutes; lat $< 0.5°$, lon $< 0.25°$
    - 8 nadir dwells per minute for up to 10 minutes
    - VZA $< 0.2°$
    - Unprecedented spatial match of measurements
    - High confidence mean radiances (average of 330 footprints)
    - Selection of uniform scene types for scheduling
    - Complementing simultaneous observations
    - Impossible to predict the cloud coverage beforehand

Trailblazer comparison opportunity in remote sensing

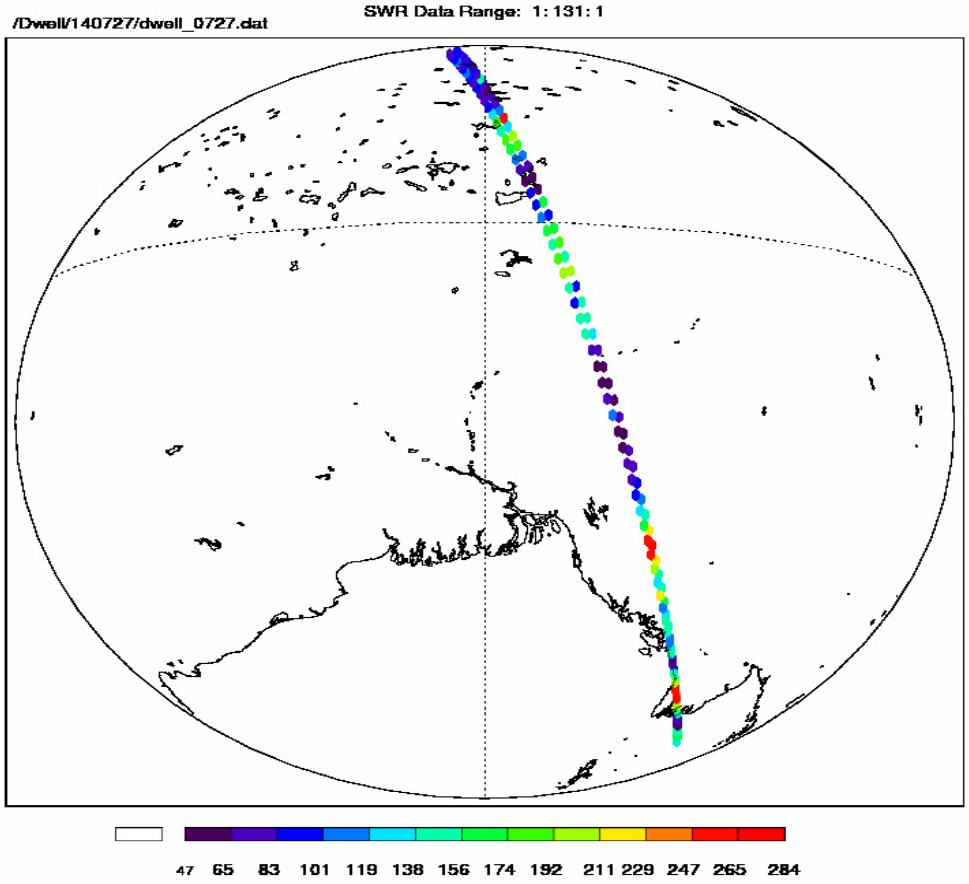
Nadir dwell scan profile



A factor of 3 higher precision of an average radiance then for a cross-track gridded average

Example of nadir dwells

Central Asia on 07/27/2014 (daytime)



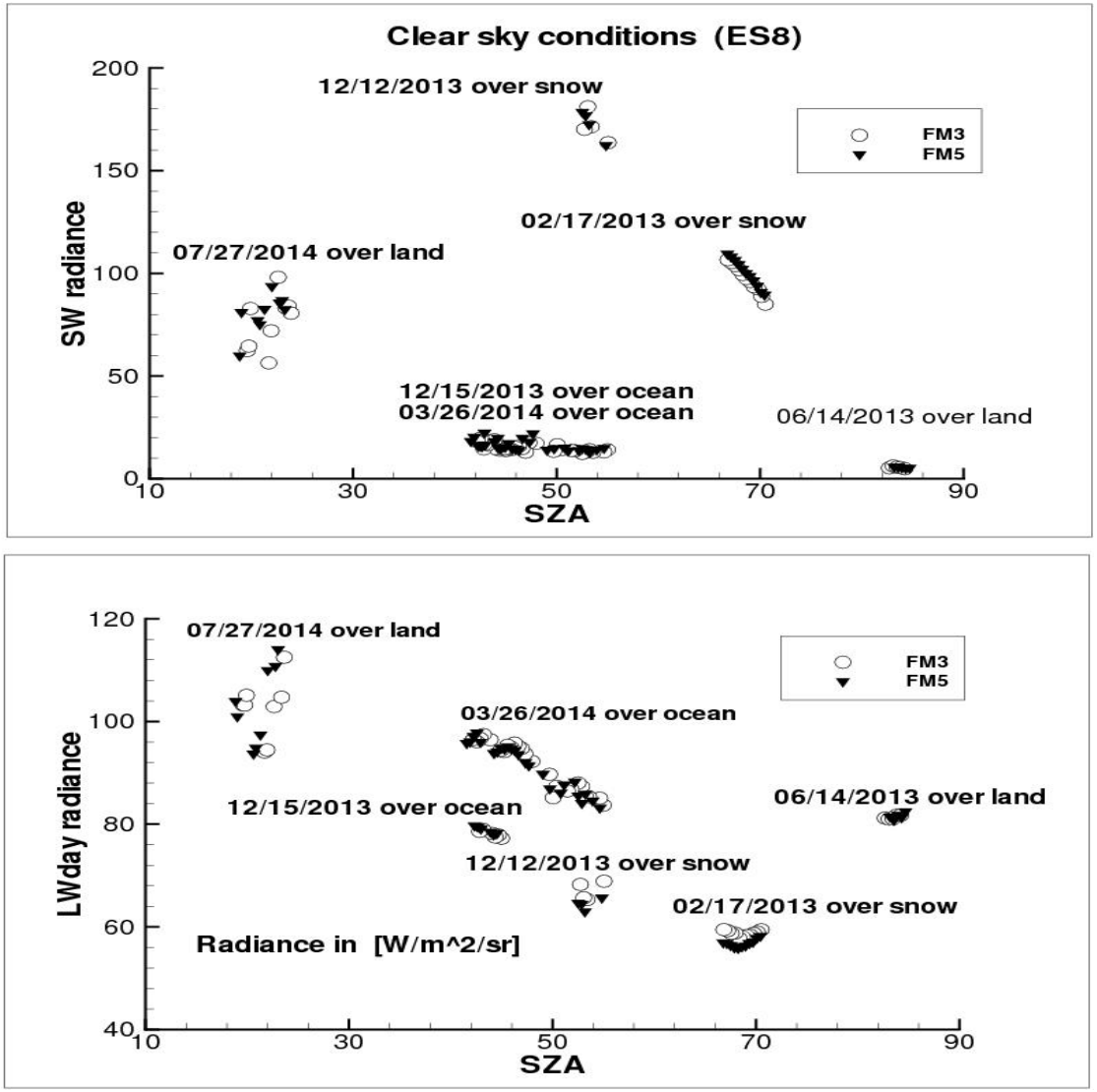
Nadir dwell experiments in 2013/2014

- 7 experiments were done in 2013
  - Antarctica daytime on 02/17
  - Alaska twilight on 06/14
  - Ocean at night on 07/17
  - Ocean daytime on 08/20, 12/12 and 12/15
  - Patagonia daytime on 10/01
- 6 experiments were done in 2014
  - Ocean-Land daytime on 03/26
  - Sahara at night on 04/01
  - Ocean daytime on 06/11
  - Central Asia daytime on 06/25, 07/19 and 07/27
- Should executing nadir dwells be resumed?

Nadir dwell experiments in 2013/2014

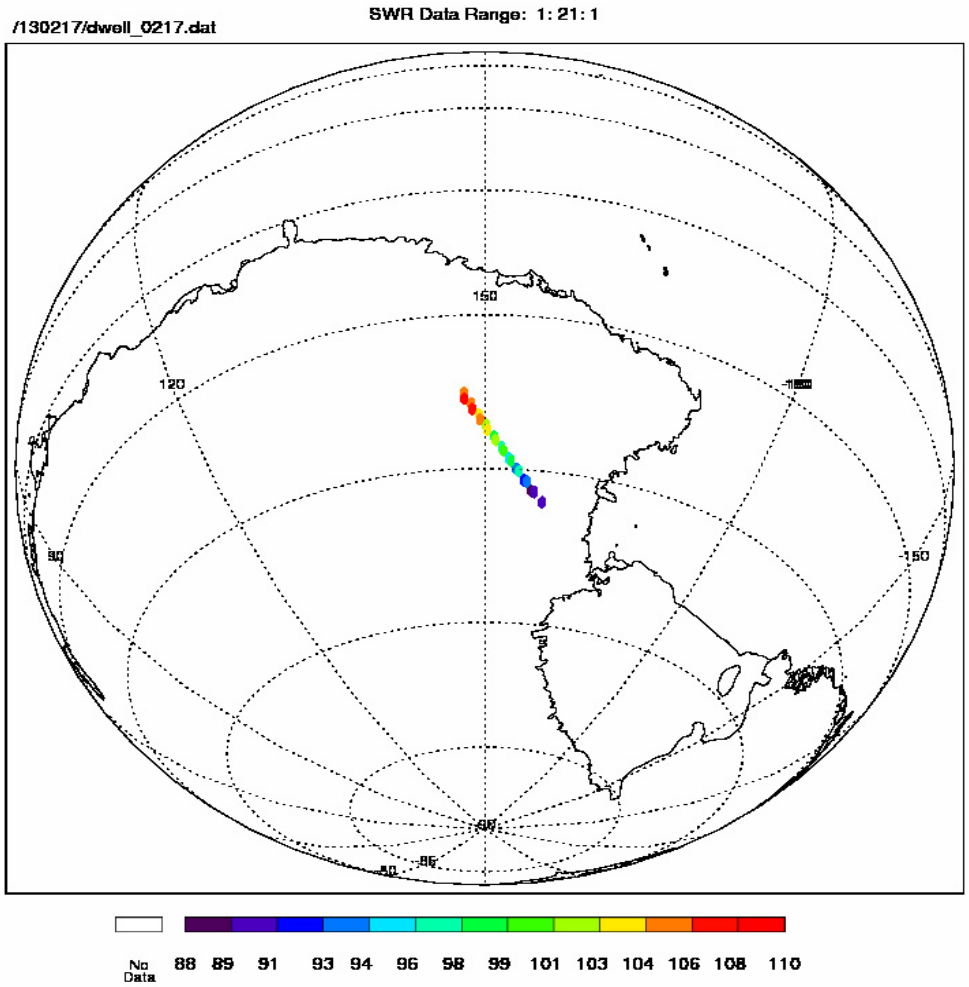
day	Geo-location	time	Num. dwells	All-cloud diff	Num. Clear-sky FM3/FM5	Clear-sky diff
02/17/13	Antarctica	daytime	11	3.0 (3.0%)	11/11 (3.2)	3.0 (3.0%)
06/14/13	Alaska	twilight	23	-1.1(-5.5%)	5/5 (2.1)	-0.1 (-1.7%)
07/16/13	N Pacific	nighttime	38	0.2(0.3%)	0 (9.0)	--
08/20/13	S Pacific	daytime	29	-6.5(-4.2%)	0 (12.0)	--
10/01/13	S Atlantic	daytime	57	3.4(3.0%)	0 (12.0)	--
12/12/13	Patagonia	daytime	29	-3.8(-2.5%)	4/4 (3.2)	-0.9 (-0.5%)
12/15/13	E Indian	daytime	56	4.2(5.3%)	10/12 (1.0)	1.5 (9.0%)
03/26/14	S Atlantic	daytime	93	1.0(1.8%)	24/27 (1.0)	1.0 (6.4%)
04/01/14	Sahara	nighttime	75	1.6(1.9%)	32 (4.3)	0.0 (0.0%)
06/11/14	Pacific	daytime	39	4.9(5.1%)	0 (12.0)	--
06/25/14	C Asia	daytime	93	1.2(0.8%)	0 (10.1)	--
07/19/14	C Asia	daytime	48	1.6(0.8%)	0 (12.1)	--
07/27/14	C Asia	daytime	66	0.7(0.8%)	10/12 (2.1)	3.1 (4.1%)

Nadir dwells with clear sky (ES8)



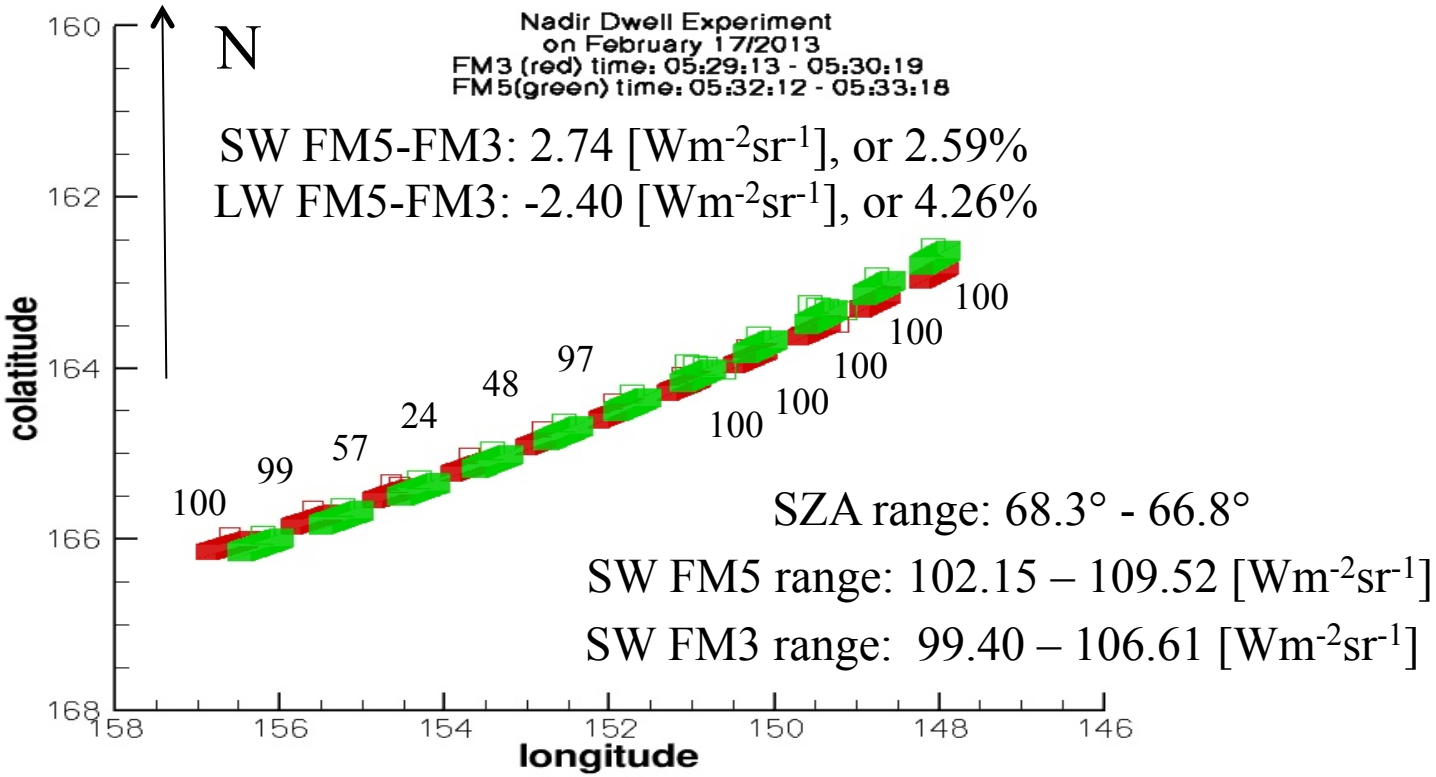
Nadir dwells over Antarctica

On 02/17/2013
(daytime)



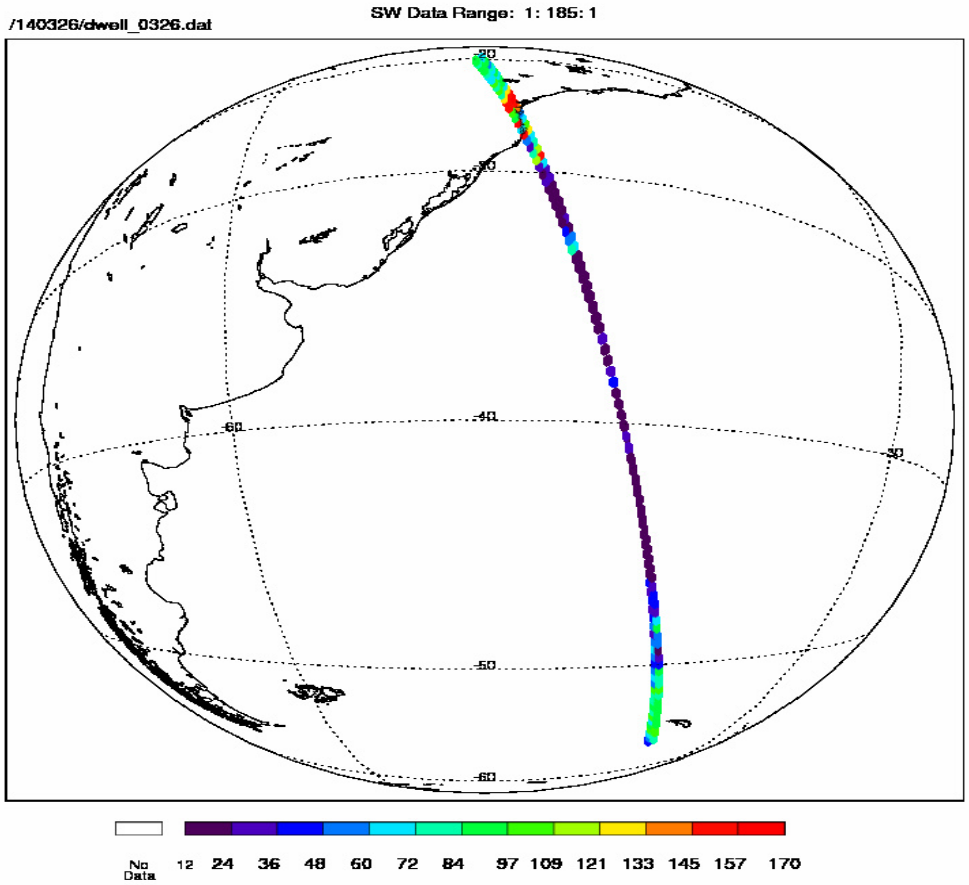
Antarctica (snow)

Only 5 consecutive clear-sky dwells are averaged



Nadir dwells over Atlantic Ocean

On 03/26/2014 (daytime)



Nadir dwells over South Atlantic

Cloud mask based only on Aqua MODIS

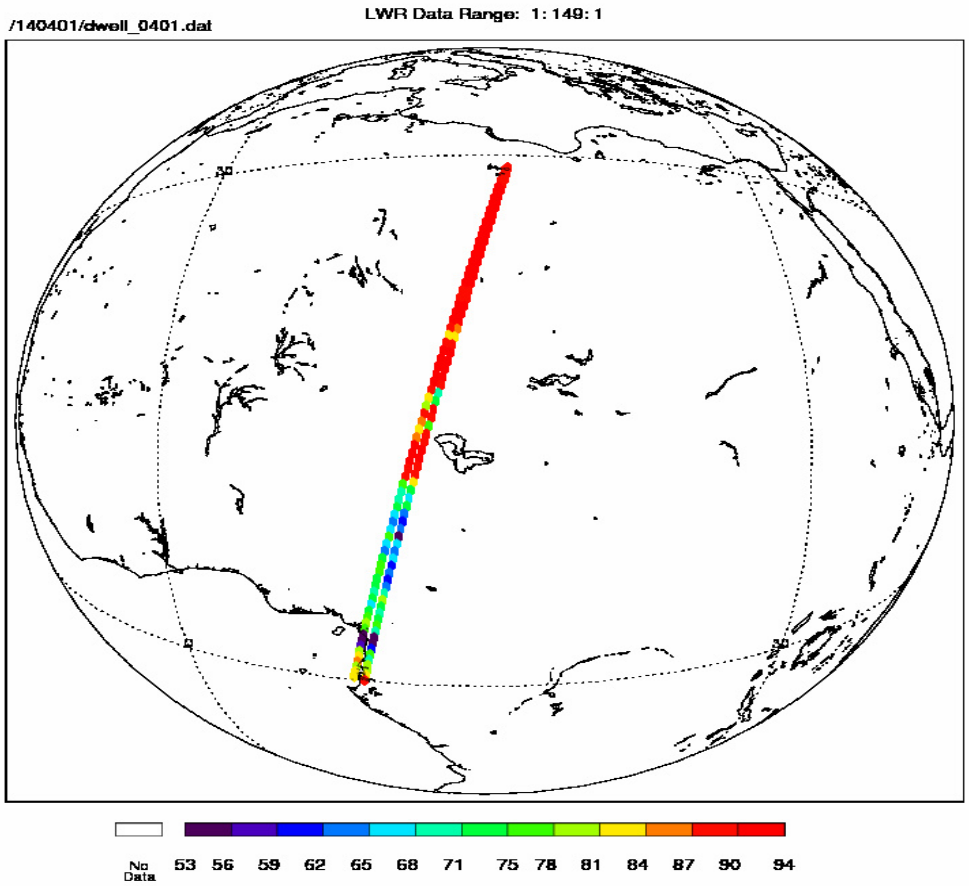
clear sky	SW FM5	SW FM3	diff	LW FM5	LW FM3	diff
99.7	13.93	12.97	0.96	94.37	94.77	-0.40
97.0	14.55	14.73	-0.18	94.69	95.19	-0.50
99.3	15.40	14.24	1.26	94.82	95.36	-0.54
99.0	15.21	14.54	0.67	94.14	94.13	0.01
98.4	14.94	14.60	0.34	93.81	94.35	-0.54
< 98.7 %>	**< 14.81 >**	**< 14.22 >**	**< 0.61 >**	**< 94.36 >**	**< 94.76 >**	**< -0.40 >**

< average > in [W/m^2/sr]

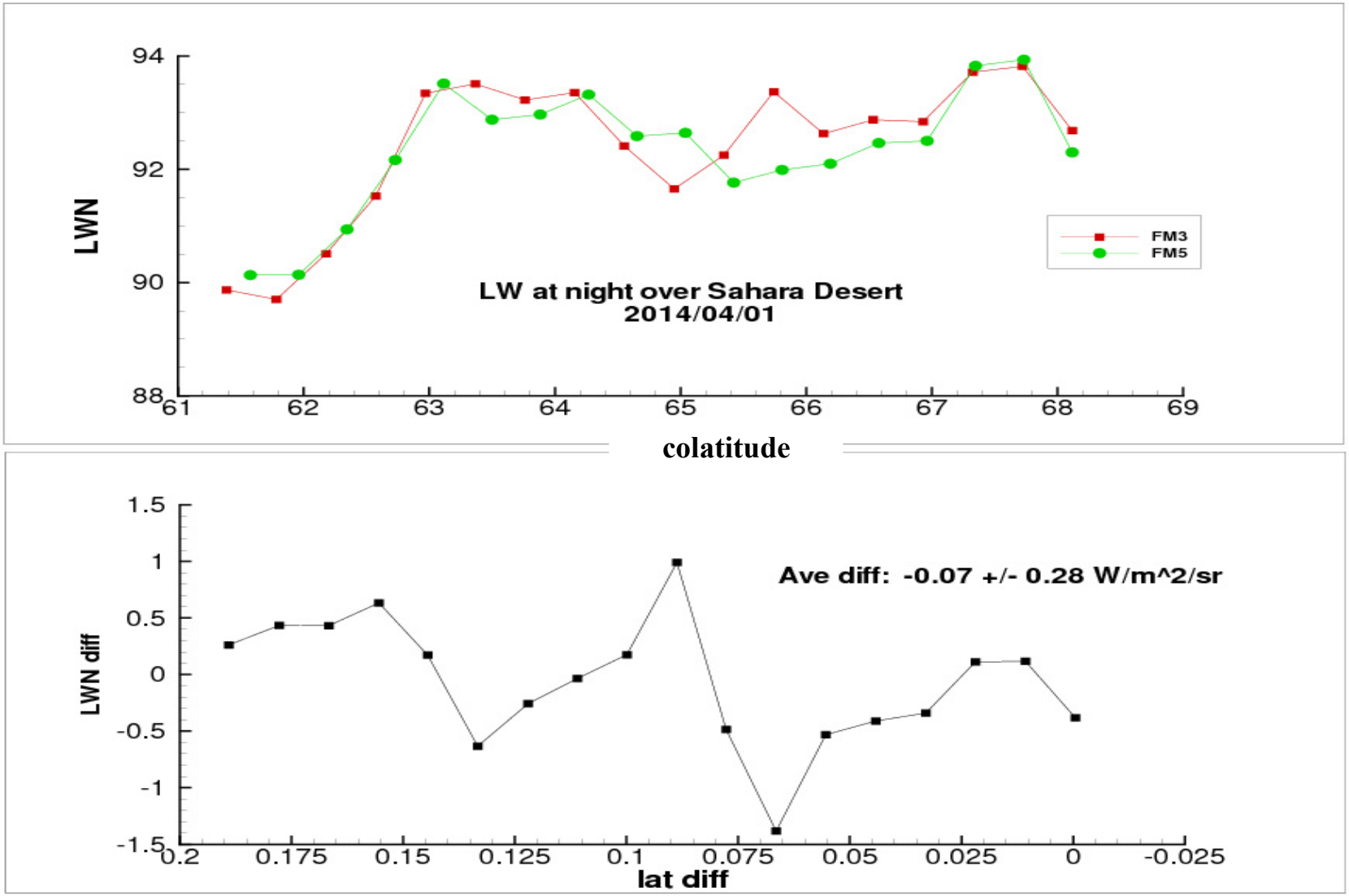
Relative difference for SW is 4.1%

Nadir dwells over Sahara Desert

On 04/01/2014
(nighttime)
18 dwells
100% clear



Clear sky at night over Sahara



Direct compare of FM5 and FM3

All-sky 2012/2013/2014

ΔTime < 1min; ΔRAZ < 10°; ΔVZA < 10°

Shown differences are statistically significant

(FM5-FM3)/ FM5	FM5 Radiance [W m^{-2} sr^{-1}]	Relative Error [%]	α-confidence [95%]	Number of samples
Shortwave	79.5/84.0/77.2	**3.35 / 2.70 / 1.02**	0.40/0.33/0.35	63/79/91
LW daytime	75.9/74.2/76.9	**-1.14 / -1.23 / -0.57**	0.09/0.10/0.13	67/82/91
LW nighttime	67.0/64.7/67.5	**-0.32 / -0.26 / 0.01**	0.09/0.08/0.06	86/98/106

- Clear-sky snow SW difference: < 2.59% > (2013)
  - Smaller than the all-sky difference
- Clear-sky ocean SW difference < 4.10% > (2014)
  - Larger than the all-sky difference
- Clear-sky desert LWN difference < -0.08 ± 0.30% > (2014)
  - The same as the all-sky difference (within the uncertainty)

Summary of results

- All 13 events have been processed
  - FM3 (Edition 4) and FM5 (Edition 1)
  - Aqua MODIS (Edition 1) for cloud coverage
  - For SW with clear sky conditions
    - FM5 is consistently greater than FM3
    - Snow/ocean difference shows spectral inconsistency
  - For LW nighttime with clear sky conditions
    - FM3 is the same as FM5 (within uncertainty)
  - Cloudy conditions can be processed when also VIIRS cloud coverage is available

Closing Remarks

- Nadir dwells of FM5 and FM3 provide
  - Tight alignments within a fraction of a degree
  - High precision averages for comparison
  - Opportunity to verify SRFs consistency
- More data would be required for any practical application
  - Winter of 2015/2016 seems to the right time to resume scheduling
- Nadir dwell data could be used on FM2
  - Radiometric signature of different scene types